REPORT #
RRTAC 87-13

An Agricultural Capability Rating System for Reconstructed Soils

Heritage Fund

Alberta

LAND CONSERVATION AND
RECLAMATION COUNCIL
Reclamation Research
Technical Advisory Committee

Report No. RRTAC 87-13

AN AGRICULTURAL CAPABILITY RATING SYSTEM FOR RECONSTRUCTED SOILS

by

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Prepared for

The Reclamation Research Technical Advisory Committee

of

THE LAND CONSERVATION AND RECLAMATION COUNCIL

1987

STATEMENT OF OBJECTIVE

The recommendations and conclusions in this report are those of the authors and not necessarily those of the Alberta Government or its representatives.

This report is intended to provide Government and Industry staff with technical information developed in 1983-84. It acts as a starting point for generating discussion on methods and procedures for developing a tool to assist in evaluating land reclamation. The report is also available to the Public so that interested individuals similarly have access to information on land reclamation topics.

ALBERTA'S RECLAMATION RESEARCH PROGRAM

The regulation of surface disturbances in Alberta is the responsibility of the Land Conservation and Reclamation Council. The Council executive consists of a Chairman from the Department of the Environment and two Deputy Chairmen from the Department of Forestry, Lands & Wildlife. Among other functions, the Council oversees programs for reclamation of abandoned disturbances and reclamation research. The reclamation research program was established to provide answers to the many practical questions which arise in reclamation. Funds for implementing both the operational and research programs are drawn from Alberta's Heritage Savings Trust Fund.

To assist in technical matters related to the development and administration of the research program, the Council appointed the Reclamation Research Technical Advisory Committee (RRTAC). The Committee first met in March 1978 and consists of eight members representing the Alberta Departments of Agriculture, Energy, Forestry, Lands & Wildlife, Environment and the Alberta Research Council. The Committee meets regularly to update research priorities, review solicited and unsolicited research proposals, arrange workshops and otherwise act as a referral and coordinating body for Reclamation Research.

Additional information on the Reclamation Research Program may be obtained by contacting:

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RECLAMATION RESEARCH REPORTS

** 1. RRTAC 80-3: The Role of Organic Compounds in Salinization of Plains Coal Mining Sites. N.S.C. Cameron et al. 46 pp.

DESCRIPTION: This is a literature review of the chemistry of sodic mine spoil and the changes expected to occur in groundwater.

** 2. RRTAC 80-4: Proceedings: Workshop on Reconstruction of Forest Soils in Reclamation. P.F. Ziemkiewicz, S.K. Takyi, and H.F. Regier. 160 pp.

DESCRIPTION: Experts in the field of forestry and forest soils report on research relevant to forest soil reconstruction and discuss the most effective means of restoring forestry capability of mined lands.

** 3. RRTAC 80-5: Manual of Plant Species Suitability for Reclamation in Alberta. 2 vols. L.E. Watson, R.W. Parker, and P.F. Polster. 541 pp.

DESCRIPTION: Forty-three grass, fourteen forb, and thirty-four shrub and tree species are assessed in terms of their fitness for use in Reclamation. Range maps, growth habitat, propagation, tolerance, and availability information are provided.

N/A 4. RRTAC 81-2: 1980 Survey of Reclamation Activities in Alberta. D.G. Walker and R.L. Rothwell. 76 pp.

DESCRIPTION: This survey is an update of the original report conducted in 1976 on reclamation activities in Alberta, and includes research and operational reclamation, locations, personnel, etc.

N/A 5. RRTAC 81-3: Proceedings: Workshop on Coal Ash and Reclamation. P.F. Ziemkiewicz, R. Stien, R. Leitch, and G. Lutwick. 253 pp.

DESCRIPTION: Presents nine technical papers on the chemical, physical and engineering properties of Alberta fly and bottom ashes, revegetation of ash disposal sites and use of ash as a soil amendment. Workshop discussions and summaries are also included.

N/A 6. RRTAC 82-1: Land Surface Reclamation: An International Bibliography. 2 vols. H.P. Sims and C.B. Powter. 292 pp.

DESCRIPTION: Literature to 1980 pertinent to reclamation in Alberta is listed in Vol. 1 and is also on the University of Alberta computing system. Vol. 2 comprises the keyword index and computer access manual.

N/A 7. RRTAC 82-2: A Bibliography of Baseline Studies in Alberta: Soils, Geology, Hydrology and Groundwater. C.B. Powter and H.P. Sims. 97 pp.

DESCRIPTION: This bibliography provides baseline information for persons involved in reclamation research or in the preparation of environmental impact assessments. Materials, up to date as of December 1981 are available from the Alberta Environment Library.

N/A 8. RRTAC 83-1: Soil Reconstruction Design for Reclamation of Oil Sand Tailings. Monenco Consultants Ltd. 185 pp.

DESCRIPTION: Volumes of peat and clay required to amend oil sand tailings were estimated based on existing literature. Separate soil prescriptions were made for spruce, jack pine, and herbaceous cover types. The estimates form the basis of recently initiated field trials.

N/A 9. RRTAC 83-3: Evaluation of Pipeline Reclamation Practices on Agricultural Lands in Alberta. Hardy Associates (1978) Ltd. 205 pp.

DESCRIPTION: Available information on pipeline reclamation practices was reviewed. A field survey was then conducted to determine the effects of pipe size, age, soil type, construction method, etc. on resulting crop reproduction.

N/A 10. RRTAC 83-4: Proceedings: Effects of Coal Mining on Eastern Slopes Hydrology. P.F. Ziemkiewicz. 123 pp.

DESCRIPTION: Technical papers are presented dealing with the impacts of mining on mountain watersheds, their flow characteristics and resulting water quality. Mitigative measures and priorities were also discussed.

N/A 11. RRTAC 83-5: Woody Plant Establishment and Management for Oil Sands Mine Reclamation. Technical Engineering Ltd. 124 pp.

DESCRIPTION: This is a review and analysis of information on planting stock quality, rearing site preparation, planting and procedures necessary to ensure survival of trees and shrubs in oil sand reclamation.

*** 12. RRTAC 84-1: Land Surface Reclamation: A Review of International Literature. 2 vols. H.P. Sims, C.B. Powter, and J.A. Campbell. 659 pp.

DESCRIPTION: Nearly all topics of interest to reclamation including mining methods, soil amendments, revegetation, propagation and toxic materials are reviewed in light of the international literature.

** 13. RRTAC 84-2: Propagation Study: Use of Trees and Shrubs for Oil Sand Reclamation. Techman Engineering Ltd. 58 pp.

DESCRIPTION: This report evaluates and summarizes all available published and unpublished information on large-scale propagation methods for shrubs and trees to be used in oil sand reclamation.

* 14. RRTAC 84-3: Reclamation Research Annual Report - 1983. P.F. Ziemkiewicz. 42 pp.

DESCRIPTION: This report details the Reclamation Research Program indicating priorities, descriptions of each research project, researchers, results and expenditures.

** 15. RRTAC 84-4: Soil Microbiology in Land Reclamation. 2 vols. D. Parkinson, R.M. Danielson, C. Griffiths, S. Visser, and J.C. Zak. 676 pp.

DESCRIPTION: This is a collection of five reports dealing with reestablishment of fungal decomposers and mycorrhizal symbionts in various amended spoil types.

** 16. RRTAC 85-1: Proceedings: Revegetation Methods for Alberta's Mountains and Foothills. P.F. Ziemkiewicz. 416 pp.

DESCRIPTION: Results of long-term experiments and field experience on species selection, fertilization, reforestation, topsoiling shrub propagation and establishment are presented.

* 17. RRTAC 85-2: Reclamation Research Annual Report - 1984. P.F. Ziemkiewicz. 29 pp.

DESCRIPTION: This report details the Reclamation Research Program indicating priorities, descriptions of each research project, researchers, results and expenditures.

** 18. RRTAC 86-1: A Critical Analysis of Settling Pond Design and Alternative Technologies. A. Somani. 372 pp.

DESCRIPTION: The report examines the critical issue of settling pond design and sizing and alternative technologies. An executive summary outlines the findings.

** 19. RRTAC 86-2: Characterization and Variability of Soil Reconstructed after Surface Mining in Central Alberta. T.M. Macyk. 146 pp.

DESCRIPTION: Reconstructed soils representing different materials handling and replacement techniques were characterized and variability in chemical and physical properties was assessed. The data obtained indicate that reconstructed soil properties are determined largely by

parent material characteristics and further tempered by materials handling procedures. Mining tends to create a relatively homogeneous soil landscape in contrast to the mixture of diverse soils found before mining.

* 20. RRTAC 86-3: Generalized Procedures for Assessing Post-Mining Groundwater Supply Potential in the Plains of Alberta - Plains Hydrology and Reclamation Project. M.R. Trudell and S.R. Moran. 30 pp.

DESCRIPTION: In the Plains region of Alberta, the surface mining of coal generally occurs in rural, agricultural areas in which domestic water supply requirements are met almost entirely by groundwater. Consequently, an important aspect of the capability of reclaimed lands to satisfy the needs of a residential component is the post-mining availability of groundwater. This report proposes a sequence of steps or procedures to identify and characterize potential post-mining aquifers.

** 21. RRTAC 86-4: Geology of the Battle River Site: Plains Hydrology and Reclamation Project. A Maslowski-Schutze, R. Li, M. Fenton and S.R. Moran. 86 pp.

DESCRIPTION: This report summarizes the geological setting of the Battle River study site. It is designed to provide a general understanding of geological conditions adequate to establishe a framework for hydrogeological and general reclamation studies. The report is not intended to be a detailed synthesis such as would be required for mine planning purposes.

** 22. RRTAC 86-5: Chemical and Mineralogical Properties of Overburden: Plains Hydrology and Reclamation Program. A. Maslowski-Schutze. 71 pp.

DESCRIPTION: This report describes the physical and mineralogical properties of overburden materials in an effort to identify individual beds within the bedrock overburden that might be significantly different in terms of reclamation potential.

* 23. RRTAC 86-6: Post-Mining Groundwater Supply at the Battle River Site: Plains Hydrology and Reclamation Project. M.R. Trudell, G.J. Sterenberg and S.R. Moran. 49 pp.

DESCRIPTION: The report deals with the availability of water supply in or beneath cast overburden at the Battle River Mining area in east-central Alberta to support post-mining land use. Both groundwater quantity and quality are evaluated.

DESCRIPTION: This report evaluates the availability of water supply in or beneath cast overburden to suuport post-mining land use, including both quantity and quality considerations. The study area is the Highvale mining area in west-central Alberta.

* 25. RRTAC 86-8: Reclamation Research Annual Report - 1985. P.F. Ziemkiewicz. 54 pp.

DESCRIPTION: This report details the Reclamation Research Program indicating priorities, descriptions of each research project, researchers, results and expenditures.

** 26. RRTAC 86-9: Wildlife Habitat Requirements and Reclamation Techniques for the Mountains and Foothills of Alberta. J.E. Green, R.E. Salter and D.G. Walker. 285 pp.

DESCRIPTION: This report presents a review of relevant North American literature on wildlife habitats in mountain and foothills biomes, reclamation techniques, potential problems in wildlife habitat reclamation, and potential habitat assessment methodologies. Four biomes (Alpine, Subalpine, Montane, and Boreal Uplands) and 10 key wildlife species (snowshoe, hare, beaver, muskrat, elk, moose, caribou, mountain goat, bighorn sheep, spruce grouse, and white-tailed ptarmigan) are discussed.

RRTAC Reports 87-1 to 87-12 are in preparation.

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PREFACE

This is one of a series of reports that presents the findings of the Plains Hydrology and Reclamation Project (PHRP), an interdisciplinary study that focuses primarily on hydrologic aspects of reclamation of surface coal mines in the Plains of Alberta. This research has been conducted by the Alberta Research Council, as part of the Alberta Government's Reclamation Research Program. The program is managed by the Land Conservation and Reclamation Council and is supported by the Heritage Trust Fund.

The focus of the PHRP is to develop a predictive framework that will permit projection of success for reclamation and impact of mining on water resources on a long-term basis. The predictive framework is based on an understanding of processes acting within the landscape so that, in the future, mine sites that are not totally analogous to those that have been studied can be evaluated as well.

The project involves a holistic approach to reclamation by integration of studies of geology, hydrogeology, and soils, not only in the proposed mining area, but also in the adjoining unmined areas. This approach permits the assessment of impacts and of long-term performance, not only in reclaimed areas, but also in the surrounding area.

The research of the PHRP was directed toward the following two major objectives and eight subobjectives during the first phase of study.

Objective A

To evaluate the potential for reclamation of lands to be surface mined. The focus is on features of the landscape that make it productive in a broad sense not restricted to revegetation. This objective was organized into five subobjectives.

1. To assess and evaluate the potential for long-term degradation of reclaimed soils through salt buildup.

2. To assess and evaluate the effectiveness of topographic modification and selective placement of materials to mitigate deleterious impacts on chemical quality of groundwater.
3. To assess the availability of water supply in or beneath cast overburden to support post-mining land use, including both quantity and quality considerations.
4. To evaluate the productivity potential (capability) of post-mining landscapes and the significance of changes in capability as a result of mining.
5. To assess and evaluate limitations to post-mining land use posed by physical instability of cast overburden.

Objective B

To evaluate the long-term impact of mining and reclamation on water quantity and quality. This objective was organized into three subobjectives.

1. To assess and evaluate the long-term alteration of quality of groundwater in cast overburden and surface water fed from mine spoil as a result of the generation of weathering products.
2. To assess and evaluate infiltration, groundwater recharge, and groundwater-surface water interactions within cast overburden.
3. To characterize the groundwater chemistry generated within cast overburden.

Studies directed at these objectives began in 1979 at the Battle River site in east-central Alberta. Work began in 1982 at a second study area at Highvale Mine south of Lake Wabamun. Significant progress had been made on all project objectives by the end of the first phase of study in March 1984. This present series of reports summarizes the state of our knowledge at the end of this first phase of study. Work is now continuing on the Phase II

objectives to gain an even greater understanding of the complex physical and chemical processes in reclaimed landscapes.

This report presents a part of the results of Subobjective A-4, to evaluate the productivity potential (capability) of post-mining landscapes and the significance of changes in capability as a result of mining. The first step in assessing the capability of reconstructed soils involved the description and characterization of the physical and chemical properties of the soils. This description and characterization is documented in a report entitled "Characterization and Variability of Soils Reconstructed after Surface Mining in Central Alberta" by T.M. Macyk (RRTAC Report No. 86-2). The next step involved the development of a system for assessing the agricultural capability of reconstructed soils. This report provides the details associated with and the potential application of the system developed.

ABSTRACT

A system for assessing the agricultural capability of reconstructed soils was developed. It parallels the Canada Land Inventory (CLI) soil capability for agriculture rating system that is currently used to rate soil capability in Alberta. The reconstructed soil capability rating system is based upon climate, landscape, and soil factors. Seven classes and 11 subclasses are defined in the system. Criteria for placing reconstructed soils into soil capability classes for dryland agricultural uses are provided. The system is applicable to all disturbances in the Plains region or in any areas where production of agricultural crops is considered as an end-land use after disturbance. A description of how to apply the reconstructed soil capability rating system is provided.

ACKNOWLEDGEMENTS

The research undertaken by the Plains Hydrology and Reclamation Project was sponsored by Reclamation Research Technical Advisory Committee of the Alberta Land Conservation and Reclamation Council, with financial support from the Alberta Heritage Trust Fund. The co-operation of Alberta Power Limited, Luscar Limited, and Manalta Coal Limited to the goals of this study are also noted.

1. INTRODUCTION

This report provides the rationale and a system for assessing the agricultural capability of reconstructed soils. During the proposal stage of the Plains Hydrology and Reclamation Project (PHRP), it was felt that the concept of productivity was one that could be utilized in comparing premining and post-mining situations. Productivity is largely dependent upon management which involves determining the kind and levels of inputs that may be appropriate to sustain desirable yields, etc.

Although it is feasible to measure productivity, it appears more appropriate, initially, to characterize reconstructed soils and determine their suitabilities and limitations for agricultural production. Soils created by the mining process are different from soils that existed prior to mining; the major difference being that minesoils or reconstructed soils have no pedogenic profile development and are characterized mainly by materials handling procedures (Macyk 1986; Schafer 1982). The variability of reconstructed soils has been assessed by Macyk (1986) and Schafer (1979). The real issue associated with this exercise is the assessment of the extent to which capability has changed as a result of the manipulation. To this end, there must be a response to the hypothetical question. If reconstructed soils have chemical and physical properties similar to that of undisturbed soils, are they likely to behave similarly in terms of land use capability?

2. DEVELOPING THE SYSTEM

The development of a capability rating system for reconstructed soils is based largely upon evaluating various parameters or properties and then comparing the results to similar parameters or properties of undisturbed soils. This will allow one to attempt to predict how the soils will respond in terms of use.

Any such system that is developed must have a "common thread" with a system that is utilized to rate the capability of natural or undisturbed soils so that meaningful concepts can be developed and relevant comparisons made. A system that is presently used to rate soil capability in Alberta is the Canada Land Inventory (CLI) soil capability for agriculture rating system (Canada Land Inventory 1965). The system that is proposed for reconstructed soils will essentially parallel the CLI system. The CLI soil capability system for agriculture is an interpretive grouping that can be made from soil survey information wherein mineral soils are grouped into seven classes according to their potential and limitations for agricultural use. The first three classes are capable of sustained production of common cultivated crops, the fourth class is considered marginal, the fifth is capable for use as permanent pasture and for hay, the sixth is capable of use for native grazing, and the seventh class has no capability or potential for agricultural use. Therefore, if there is to be any continuity between the existing CLI, which assesses the suitability of a soil for a given use prior to disturbance, then the system or component classes associated with reconstructed soils must reflect respectively similar capability. For example, a CLI Class 1 and a Reconstructed Class 1 should reflect similar capability.

It must be stressed that the CLI rating system is based on soil survey data of relatively stable soils that are generally not undergoing major change in a short time. In contrast, the data obtained in characterizing reconstructed soils represent a point source in time for any given parameter. Some of these parameters are likely to change more rapidly than others within a given time frame.

The application of a particular rating, therefore, is based on the properties of the reconstructed soils determined or assumed at a specific time.

It is of paramount importance that all users understand and accept the concept that change is bound to occur in these reconstructed soils and the appropriate capability rating associated therewith will also change. Also, the capability system and, therefore, any particular rating assigned, is based on existing conditions and not on what the conditions are perceived or predicted to be some time hence. Further research that will allow for an assessment or quantification of change in reconstructed soils will provide for the development of better or more exact rating schemes, or ones that are or can be more predictive.

The system that is developed should be considered applicable to all mines (disturbances) in the Plains region or in any region that is suitable for agricultural crops. This is indeed a "stand alone" system that is not based on premining capability of a particular site. It can be suggested, however, that if premining capability is relatively low or poor, then it is likely that post-mining capability will also be relatively low. Some exceptions will undoubtedly occur; for example, if capability prior to disturbance is low, primarily because of topographic or drainage limitations, then there is a strong possibility that post-mining topography and drainage will be more amenable to a better or higher rating.

3. ADAPTING THE CLI SYSTEM

The CLI system of rating soils is based upon climate, landscape, and soil factors. It follows, therefore, that reconstructed soils should be rated on the basis of similar factors. The descriptions of class and subclass as defined by CLI (Brocke 1977) follow.

The class indicates the general suitability of the soils for agricultural use.

3.1 SOIL CAPABILITY CLASSES

Class 1 - these soils have no significant limitations for crop use

Class 2 - these soils have moderate limitations that restrict the range of crops or require moderate conservation practices

Class 3 - these soils have moderately severe limitations that restrict the range of crops or require special conservation practices

Class 4 - these soils have severe limitations that restrict the range of crops that can be grown or require special conservation practices to overcome, or both

Class 5 - these soils have very severe limitations that restrict their capability for producing perennial forage crops, but improvement practices are feasible

Class 6 - these soils are only capable of producing perennial forage crops and improvement practices are not feasible

Class 7 - these soils or land types have no capability for arable culture or permanent pasture.

It must be emphasized that soils within a capability class are similar only in the degree or intensity of limitation and not the kind of limitation. Each class includes many different kinds of

soils and many of the soils within any one class may require different management practices.

3.2 SOIL CAPABILITY SUBCLASSES

The subclass is a grouping of soils with the same kind of limitation. It provides information on the kind of conservation problem or limitation. When used together, the class and subclass provide information about the degree and kind of limitation. Fourteen different kinds of limitations are recognized as a result of adverse climate, soil, or landscape characteristics. The limiting effects of the climate are considered first since they affect the initial capability class or degree of limitation on a broad sub-regional basis. Next, the soil and landscape limitations are considered. The subclass limitations are described in Table 1.

Application of the existing CLI system requires the ability to recognize kind of limitation and evaluate the degree or intensity of limitation. It should be noted that there is a lack of specificity associated with the system, and that in many instances subjective evaluations must be made. The system outlines criteria for 14 kinds of limitations, some defined more quantitatively than others. For example, climate is based on factors such as precipitation and frost-free period, which are defined to some extent, whereas fertility is based in a general fashion on parent material type.

As is done in the CLI system, the degree of climatic limitation is used to establish the base level or starting point in developing and applying the reconstructed soil capability rating system. The logic, simply stated, is that the climate that applies to the predisturbance also applies for the post-disturbance situation. The primary climatic factors include the amount and distribution of precipitation, the length of the growing season and frost-free period, and the quantity of heat units available for plant growth. The definition of the climatic classes and the criteria used to characterize these are set forth in Table 2.

Table 1. Definition of subclasses.

Climatic Limitations:	expressed on the basis of adverse sub-regional climate where there are no other significant limitations
Subclass A	- moisture deficiency due to insufficient precipitation
Subclass B	- heat deficiency expressed in terms of length of the growing season and cumulative degree days over 42°F
Soil Limitations:	caused by unfavourable inherent soil characteristics
Subclass D	- undesirable soil structure and/or slow permeability
Subclass F	- low inherent fertility status
Subclass M	- low available moisture holding capacity
Subclass N	- excessive soil salinity
Subclass S	- unfavourable soil characteristics; used in a collective sense where two or more of the above are present and/or in addition to some other limitation
Landscape Limitations:	
Subclass E	- erosion damage
Subclass I	- inundation
Subclass P	- excessive stoniness
Subclass R	- shallowness to consolidated bedrock
Subclass T	- adverse topography; both steepness and pattern
Subclass W	- excessive moisture
Subclass X	- cumulative effect of two or more of the above that singly are not severe enough to affect the rating

Table 2. Definition of climatic classes.

Class	Description	Precipitation	Frost-Free Period (Days)	Degree Days above 42°F
1	Sufficient precipitation and length growing season to adequately mature wheat	40 to 45 cm (16 to 18 in)	90	2200
2	Moderate climatic limitations due, either, to a lack of precipitation or a shortened growing season, or both	Adequate only 50% of the time	75 to 90	1900 to 2200
3	Moderately severe limitation due to a lack of precipitation or shortened growing season, or both	30 cm (12 in) or less	60 to 75	1750 to 1900
5	Very severe limitations due to a very short growing season		60	1750

It should be emphasized that Table 2 is a general guide that was originally developed to characterize climate over relatively large areas. Utilizing this general guide to climatic characteristics, the initial or base-level capability of an area can be established. For example, in Climatic Area 1 the highest capability rating would be Class 1 with favourable soils and landscape conditions. Class 1 represents the starting point and any area within Climatic Area 1 with adverse soil and/or landscape characteristics is downgraded, accordingly. Similarly, in Climatic Area 3, the highest capability rating that could be assigned is Class 3, even though there are no limitations in soil and landscape characteristics.

After establishing the base-level capability of an area, as determined by climate, the next step is to evaluate the properties of the reconstructed soils and the landscapes which affect agricultural use. Assessment of topographic limitation includes evaluation of the hazards imparted to cultivation by the degree of slope, as well as irregularity of field patterns and lack of soil uniformity resulting from complex landform patterns. This is a limiting factor especially in those areas where no spoil leveling has occurred, and limiting to a lesser extent in those areas where partial leveling was undertaken. In the level and gently undulating areas a limitation due to pattern may result from the occurrence of small, poorly drained areas that are often due to the leveling procedure or differential settlement. These small areas affect the efficiency and effectiveness of, for example, cultivation and harvesting procedures. The criteria used for evaluating topographic limitations for CLI can be utilized in this system and are described in Table 3.

Additional landscape features or limitations can be broadly defined. Excessive moisture may be the result of poor soil drainage, a high water table, seepage, or the collection of runoff from surrounding areas. In reconstructed soil areas, poorly drained features are often the direct result of differential settlement. The degree of limitation is dependent on the duration of the period that these

Table 3. Definition of capability class relative to climatic area and slope class.

Slope Class and %	Climatic Area	Degree of Limitation (Capability Class) Simple Slopes	Complex Slopes
Aa and Bb[a]	1	1	1
0 to 2	2	2	2
	3	3	3
	5	5	5
Cc	1	1	2
2 to 5	2	2	2
	3	3	3
	5	5	5
Dd	1	2	3
5 to 9	2	2	3
	3	3	3
	5	5	5
Ee	1	3 or 4[b]	4
9 to 15	2	3 or 4[b]	4
	3	4	4
	5	5	5
Ff	1	5	5
15 to 30	2	5	5
	3	5	5
	5	6	6
Gg and Hh greater than 30		6 to 7[c]	6 to 7[c]

[a] Uppercase letter - simple slopes; lower case letter - complex slopes.

[b] Depending on nature of material and susceptibility to erosion.

[c] Depending on natural grazing potential for domestic animals.

soils remain wet as it affects the timing of cultivation, seeding, and harvest.

The CLI system does not define the soil factors or limitations to the extent that topography and climate are defined. The approach adopted in developing criteria for determining the suitability or limitation of various soil properties is to consider general guidelines already established (Agriculture Canada 1978; Schafer 1979) and to assess what it is that makes "normal" or undisturbed soils fit into the various classes and subclasses. Alternatively, it can be expressed as an assessment of the characteristics of soils that are placed in specific classes.

The following discussion describes the limitation subclasses developed by CLI and provides information applicable to reconstructed soils.

Undesirable soil structure and/or low permeability is a limitation for some of the reconstructed soils. In terms of undisturbed soils, this limitation is most commonly utilized for soils prone to crusting, which tends to inhibit seedling emergence and may restrict soil aeration. Similarly, the illuvial horizons or subsoil of some soils (generally fine textured) also present structural limitations that are restrictive to internal drainage and root penetration.

The reconstruction process alters "normal" or pedologically developed structures. The effects of this alteration vary depending upon the soils involved. In terms of orthic soils, the effect is likely to be negative or a diminution of the predisturbance characteristics. On the other hand, Solonetzic soils and others characterized by a dense subsoil are likely improved by the reconstruction process. Reconstructed soils that have not been topsoiled are certainly prone to crusting, which tends to inhibit seedling emergence. Research conducted by other investigators within the PHRP suggests that infiltration is not necessarily restricted in reconstructed soils.

Low inherent fertility status is a limitation that has been applied to Alberta soils on a very restricted basis. This limitation is difficult to assess without laboratory data to evaluate fertility status and, generally, the application of this subclass has been confined to soils developed on very sandy parent materials.

Those areas where topsoil is applied to reconstructed soils likely will not have any major deficiencies. In those areas where topsoil is not applied, the soils are likely to show deficiencies, however, other subclasses or factors are likely to become limiting before fertility. Furthermore, nutrient deficiencies are relatively easily corrected.

Low available moisture holding capacity is generally associated with sandy soils. It does not appear, however, that this is of major concern at the Battle River or Highvale sites.

The excessive soil salinity limitation applies to soils in which the content of soluble salts is sufficient to adversely affect crop growth or to restrict the range of crops that can be grown (salt tolerance). This subclass is frequently used in combination with the landscape limitation for excessive wetness, and in areas of Solonetzic soils where the salts occur very near the surface. This subclass has also been used in combination with the undesirable soil structure and/or low permeability limitation. Levels of salinity have not been quantified relative to the decision of whether or not to attach a limitation (or not).

Some quantification is presented for reconstructed soils in order that the limitation can be appropriately assessed or applied. This was done by reviewing the literature and assessing the salinity and sodicity levels of undisturbed soils to which the limitation has been applied.

The erosion damage limitation has been applied in evaluating soils where actual damage by erosion (wind or water) has resulted in a limitation to agricultural use. Damage is assessed for both the restriction to the range of crops that can be grown, and the mechanical difficulties presented to farming.

Presently, erosion does not appear to be a significant problem in the areas of reconstructed soils, except for the unleveled spoil piles. The steeply sloping areas in existence have had relatively successful revegetation. If these areas were not revegetated there is a strong possibility of severe erosion occurring. To a large extent, however, these areas represent closed systems, meaning that material moving down any of the slopes is trapped or contained within the "between pile" depressions.

The inundation limitation has been applied to areas subject to inundation by lakes or streams, but not to depressional areas subject to ponding. This limitation is not likely to be a major concern in areas of reconstructed soils.

The excessive stoniness limitation has been applied to soils that are sufficiently stony to hinder agricultural activities. Soils with surface stoniness ratings of S3, S4, and S5 as defined in the Canadian System of Soil Classification (Canada Soil Survey Committee 1978) have limitations to agricultural use.

This subclass would rarely apply as the dominant limitation for reconstructed soils. When soils are reconstructed for use, one of the procedures employed in preparing the landscape for cropping and other agricultural activities is to remove stones that are likely to impede these activities.

The shallowness to consolidated bedrock limitation applies in areas where consolidated bedrock restricts the depth of the rooting zone. This limitation does not often apply within the agricultural areas.

The concern associated with reconstructed soils relates to the presence of an adequate root zone layer. An adequate root zone could be defined as a layer approximately 1.5 m thick which does not have restrictive zones or layers characterized by very high bulk densities. One concern that surfaces relative to a similar problem is that of the "traffic pan" which occurs in reconstructed landscapes. This is a layer of higher density which occurs approximately

in the 25 to 75 cm depth range and where bulk density is greater than that of the material above or below this "layer".

Field observations indicate that there is an increase in the bulk density in the traffic pan zone; however, ripping does not appear to change the situation to any major extent. The effects of the traffic pan are diminished rapidly (in two or three years) by the freeze-thaw processes and cropping. The traffic pan does not hinder infiltration/percolation because there are adequate macropores present to allow for the orderly movement of water through and away from this zone.

4. CRITERIA FOR PLACING RECONSTRUCTED SOILS INTO CAPABILITY CLASSES

The soil and soil/landscape limitations of the CLI system, along with their implications for reconstructed soils, have been defined. To develop an overall rating system, some of the soil and soil/landscape parameters must be quantified to some extent in a relative manner. Suitability rating tables that provide good, fair, and poor ratings for various physical and chemical properties already exist and are described in a number of publications (Alberta Soils Advisory Committee 1981; Schafer 1979).

Table 4 presents criteria for placing reconstructed soils into soil capability classes for dryland agricultural uses. Included along with the soil parameters are the topography and climate considerations. To determine capability class, the top 1 m of the reconstructed soil is evaluated on the basis of the parameters included in the table. One metre was chosen in part because the literature indicates that the majority of plant roots occur in the upper 25 to 60 cm of soil. Annual crops such as cereals do not grow actively in the soil long enough to develop a really deep root system, and in temperate countries rooting does not normally exceed 1 to 1.5 m (Russell 1973). Furthermore, it is generally the top metre of unmined soils that is considered in developing CLI ratings.

The properties of the top metre of reconstructed soil are considered as one unit. For example, to determine the EC value that is applied against the rating table one would calculate a mean value of the results obtained for various samples obtained within the 1 m depth. The same approach is taken to consider pH, texture, and SAR in terms of developing or determining ratings. There is the concern that an unusually high or unusually low value will distort the overall mean. In these instances it is up to the rater's discretion as to whether or not these types of values are considered in developing mean values and thereby the ultimate rating of suitability or limitation of a specific parameter.

Table 4. Criteria for placing reconstructed soils into capability classes for dryland agricultural uses.

Class	Climate (Class)	Topography (Slope %)	Topsoil[1] Thickness (cm)	Soil Texture (Upper 1 m)	Stoniness[2] (Class)	Drainage[3] Class	Reaction (pH)	EC (mS/cm)	SAR	Erosion[4]
R1	1	0 to 2	>15	L, VFSL	S0 to S1	MW to W	6.0 to 7.5	<2	<4	W1
R2	2	2 to 6	5 to 15	FSL, SCL, SiL	S0 to S1	MW to W	5.5 to 6.0	2 to 4	4 to 8	W1
R3	3	5 to 9	0+ to 5	SC, CL	S2	I	5.0 to 5.5	2 to 4	8 to 12	W2
R4	3	9 to 15	0	SiCL	S3	I, R	8.5 to 9.0	4 to 8	12 to 20	W2
R5	5	15 to 30	0	LS, SiC, C	S4	P, VR	8.5 to 9.0	4 to 8	12 to 20	W3
R6		30 to 60		S, HC	S5	VP	4.5 to 5.0	8 to 12	20 to 50	W4
R7		>60		Any		Water	<4.5 >9.0	>12	>50	

[1] Topsoil thickness: amount of Ah (Ap) organo-mineral material replaced on surface.

[2] Stoniness class: S0 = nonstony; S1 = slightly stony; S2 = moderately stony; S3 = very stony; S4 = exceedingly stony; S5 = excessively stony. Further definition of classes provided in Can SIS Manual for describing soils in the field (1982).

[3] Drainage class: VR = very rapid; R = rapid; W = well; MW = moderately well; I = imperfect; P = poor; VP = very poor.

[4] Erosion: W1 = slightly eroded; W2 = moderately eroded; W3 = severely eroded; W4 = gullied. Further definition of classes provided in Can SIS Manual for describing soils in the field (1982).

Note: 1. Chemical properties in the 0 to 100 cm control section are considered in applying rating.
2. A combination of more than two limiting factors will drop soil by at least one capability class.

A better approach might allow for the splitting of the 1 m into two units, whereby the upper 40 to 50 cm are considered and weighed more heavily than the lower 50 cm in developing a capability rating. This would undoubtedly result in a relatively complex system that is perhaps not warranted at this stage.

The proposed system recognizes the presence or absence of topsoil and some considerations pertinent to its depth. Topsoil refers to the organo-mineral A horizon type of material. It can be argued that in some areas topsoil cannot be replaced because it does not occur in the predisturbance setting. An example might be areas characterized dominantly by Luvisolic soils. A reconstructed soil in this context would likely be rated a Class R3 or R4 on the basis of climate and other characteristics rather than a lack of topsoil or the presence of poor quality topsoil.

One of the properties that is not considered in the rating scheme relates to the "structure" or relative density of the reconstructed soil. Existing methods of determining bulk density are not particularly useful for characterizing reconstructed soils. The twin-probe method is appropriate, but its practical use is limited because of the nature of the equipment installations required.

It is apparent that the chemical properties of reconstructed soils are addressed to a greater extent than physical properties, and this is largely due to existing knowledge and measurement capabilities. Further, research and the development of appropriate equipment will improve the situation.

5. CHARACTERIZATION OF RECONSTRUCTED SOILS

In order to assign capability ratings to reconstructed soil areas one must complete a "characterization study" or "soil survey" to gather the necessary information. Discussion pertinent to inspection and sampling density is presented in a report by Macyk (1986). A summary of the suggested or recommended procedures is provided. Inspection density should be in the range of 1 to 5 ha/inspection. Sampling density should be in the range of 5 to 10 ha/sample site. Samples collected at each site should reflect the depth (cm) sequence of 0 to 15, 15 to 30, 30 to 45, 45 to 60, 60 to 75, 75 to 90, 90 to 120, 120 to 150, or a reasonable facsimile thereof. It was stated previously that capability ratings should be assigned on the basis of the physical and chemical properties of the upper 1 m. However, it is very useful to have information about the additional 50 cm suggested by the depth sequence proposed, especially because, with present soil reconstruction procedures, the subsoil/spoil interface generally occurs within the 120 to 150 cm depth.

Because a mean value for a specific parameter, such as SAR for example, is derived from the six or seven depth sequence samples, it could be suggested that one sample representing the entire depth range be obtained and analysed. This would certainly result in a saving of analytical costs, but would not allow for an assessment of the various depth parameters.

6. DEVELOPMENT OF RECONSTRUCTED SOIL RATINGS

Capability ratings are formulated by relating the reconstructed soil properties to the criteria presented in Table 4. The class indicates the general suitability of the reconstructed soils for agricultural use. Class symbol is preceded by "R" to designate reconstructed.

6.1 RECONSTRUCTED SOIL CAPABILITY CLASSES

Class R1 - these soils have no significant limitations for crop use

Class R2 - these soils have moderate limitations that restrict the range of crops or require moderate conservation practices

Class R3 - these soils have moderately severe limitations that restrict the range of crops or require special conservation practices

Class R4 - these soils have severe limitations that restrict the range of crops that can be grown or require special conservation practices to overcome, or both

Class R5 - these soils have very severe limitations that restrict their capability for producing perennial forage crops, but improvement practices are feasible

Class R6 - these soils are only capable of producing perennial forage crops and improvement practices are not feasible

Class R7 - these soils or land types have no capability for arable culture or permanent pasture

6.2 RECONSTRUCTED SOIL CAPABILITY SUBCLASSES

The subclass represents a grouping of soils with the same kind of limitation. The criteria associated with each of the subclasses in relation to class are provided in Table 1. The

symbology associated with the subclasses designated follows:

Topsoil (Absence)	- A
Climate	- C
Erosion	- E
Reaction (pH)	- H
Soil Texture	- K
Salinity (EC)	- N
Sodicity (SAR)	- Q
Stoniness	- P
Topography and Field Pattern	- T
Drainage	- W
Adverse Soil Characteristics (Cumulative Effect)	- S

7. APPLYING THE RECONSTRUCTED SOIL CAPABILITY RATING SYSTEM

It was noted previously that there is an element of subjectiveness and, to an extent, a certain lack of specificity relative to the "definitions" associated with the CLI rating system. Furthermore, there is a certain element of subjectiveness associated with the designation of ratings for specific parcels of land.

For the reconstructed soil rating system the class and subclass criteria are defined more fully, but there is still an element of subjectiveness involved in developing the final rating designation for a specific parcel of land. The most likely time for confusion occurs when a combination of two or more limiting factors occur. A "rule of thumb" that can be applied suggests that a combination of two limiting factors does not drop capability by one class. A combination of three limiting factors will drop rating by one class or more.

Various scoring techniques were attempted to resolve the problem associated with the element of subjectiveness, however, they did not prove entirely workable or represent an improvement over the proposed technique.

Final ratings for the reconstructed soil areas designated at each of the mines are presented in Table 5 at the end of this section. First, examples are provided to demonstrate how the system should be utilized.

Example 1: Diplomat Mine RC3/b area

The field characterization data and Table 1 provide the following summary:

Climate - Class 1
Topography - Class 1
Topsoil Depth - Class 1
Texture - Class 1
Stoniness - Class 1
Drainage - Class 1
Reaction (pH) - Class 1
Salinity - Class 2

Sodicity - Class 1
Erosion - Class 1
Rating = R2N

Because salinity is the most limiting factor and the criteria fit Class 2, the rating is Class R2 with the N (salinity) limitation.

Example 2: Vesta Mine RC4/b area

The field characterization data and Table 1 provide the following summary:

Climate - Class 1
Topography - Class 1
Topsoil Depth - Class 1
Texture - Class 2
Stoniness - Class 1
Drainage - Class 1
Reaction (pH) - Class 2
Salinity - Class 2
Sodicity - Class 3
Erosion - Class 1
Rating = R3Q

Because sodicity is the most limiting factor and the criteria fit Class 3, the rating is Class R3 with the Q (sodicity) limitation.

Example 3: Highvale Mine RC4/b area

The field characterization data and Table 1 provide the following summary:

Climate - Class 2
Topography - Class 1
Topsoil Depth - Class 2
Texture - Class 1
Stoniness - Class 1
Drainage - Class 1
Reaction (pH) - Class 1
Salinity - Class 2

Sodicity - Class 3
Erosion - Class 1
Rating = R3Q

Because sodicity is the most limiting factor and the criteria fit Class 3, the rating is Class R3 with the Q (Sodicity) limitation.

Example 4: Hypothetical Case 1

Climate - Class 2
Topography - Class 2
Topsoil Depth - Class 2
Texture - Class 2
Stoniness - Class 1
Drainage - Class 1
Reaction (pH) - Class 2
Salinity - Class 2
Sodicity - Class 2
Erosion - Class 1
Rating = R3S

In this instance climate initially sets the base rating at Class 2; however, there are a number of soil related factors which fit the criteria for Class 2. Singly, these factors would not be severe enough to result in a reduction in class; however, the cumulative effect of more than two factors with Class 2 criteria results in the dropping of class to R3S. The "S" represents the cumulative effect of the soil factors.

Example 5: Hypothetical Case 2

Climate - Class 3
Topography - Class 4
Topsoil Depth - Class 4
Texture - Class 5
Stoniness - Class 3
Drainage - Class 2
Reaction (pH) - Class 2
Salinity - Class 1

Sodicity - Class 1

Erosion - Class 2

Rating = R5K

Because texture is the most limiting factor and the criteria fit Class 5, the rating is Class R5K with the K (texture) limitation.

Table 5. Reconstructed soil capability ratings.

Diplomat Mine

Reconstructed Soil Area	Rating	Reconstructed Soil Area	Rating
RC1/f-g	R6T	RC3/b	R2N
RC2/b	R4	RC3/b-c	R2N
RC2/b-c	R4	RC8/c	R2N
RC2/c	R4	RC3/b[1]	R4
RC2/c-d	R4	RC6/b-c	R4
RC2/d	R4	RC7/b	R6W
RC2/d-e	R5S	RC7/b-c	R6W
RC2/f	R5T	RC8/b[3]	

Vesta Mine

Reconstructed Soil Area	Rating	Reconstructed Soil Area	Rating
RC1/f-g	R6T	RC4/b-c	R3Q
RC2/c	R6Q	RC4/c	R3Q
RC2/d	R6Q	RC4/d	R3
RC2/e	R6Q	RC4/e	R4T
RC2/f	R6	RC5/c[4]	R6Q
RC3/c	R4Q	RC5/d	R6Q
RC3/d	R4Q	RC5/e	R6Q
RC3/e	R4Q	RC5/f	R6
RC3/f	R5T	RC6/c[1]	R6Q
RC4/b	R3Q	RC7/b[2]	R6W

Highvale Mine

Reconstructed Soil Area	Rating	Reconstructed Soil Area	Rating
RC1/g	R6T	RC4/e	R4T
RC4/b	R3Q	RC4A/b	R3 R5W
RC4/b-c	R3Q	RC6[1]	
RC4/c	R3Q	RC7/b	6W
RC4/d	R3	RC8[3]	

[1] RC6 areas could be treated the same as RC1 or RC2 areas depending on whether or not leveling has occurred. If topsoil is to be added then, initially perhaps, a rating should not be applied. RC1 areas at Vesta and RC1 and RC2 areas at Highvale were not characterized.

continued . . .

Table 5. Concluded.

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[2] RC7 areas are limited by a wetness limitation. It could be assumed that other parameters are similar to the surrounding (better drained) landscape.

[3] RC8 areas can be rated similarly to undisturbed soils. RC8 areas were not characterized by the physical and chemical parameters.

[4] RC5 areas are unique in that they have a layer of ash over leveled spoil. Characteristics of RC2 areas in addition to those related to the ash should be utilized in preparation of ratings.

[5] The Subclass T in this particular rating is utilized to demonstrate the limitation due to pattern created by the occurrence of small, poorly drained areas. The poorly drained areas which comprise approximately 40% of the unit are rated Class R5W.

8. RELATING PRODUCTIVITY TO CAPABILITY

The capability ratings that can be assigned to reconstructed soil areas allow for an ordered ranking of relative capability; however, these ratings do not provide for quantification or allow for the detailed assessment of production capacities and effects of different management techniques. This can only be accomplished through the measurement of yield. In terms of reconstructed soils, yield obtained would be a function management inputs as well as the changes that occur in the properties of these soils. Presently there exist doubts or concerns that relatively good initial productivity subsequent to soil reconstruction can be sustained.

Peters and Pettapiece (1981) indicate that there is a predictable relationship between yields of agricultural soils and CLI classes and subclasses within any one climatic zone. Now that a capability system to rate reconstructed soils has been developed which essentially parallels the CLI system for "undisturbed" agricultural soils, the ultimate question relates to comparing yields obtained from specific CLI classes and the respective reconstructed (R) classes and subclasses. In essence, the hypothesis that "reconstructed soils are as productive as unmined soils" will be tested.

Luscar Ltd. (1980, 1981, 1982, 1983) has obtained valuable data from the monitoring of crop yields under various "operational scale" revegetation programs and of yield from adjacent unmined land. They conclude that crop yields on reclaimed lands were generally similar to those on adjacent unmined lands. Review of the data indicates that there were some differences between the unmined and reclaimed areas relative to management inputs, specifically fertilizer applications. Productivity can be related to capability of the unmined soil and reconstructed soil settings, but controlled experiments will be required to provide conclusive results.

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